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APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A
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Certified by



Jon W Dudas

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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

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INVENTOR(S)		
Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
James Copland	Moyer	San Jose, California
Michael Ren	Hsing	Saratoga, California
Jean-Francois	Daviet	Fremont, California

 Additional inventors are being named on the _____ separately numbered sheets attached hereto

TITLE OF THE INVENTION (500 characters max)

**DRIVER FOR LIGHT SOURCE HAVING INTEGRATED PHOTOSENSITIVE ELEMENTS FOR
DRIVER CONTROL**

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ENCLOSED APPLICATION PARTS (check all that apply)

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| <input type="checkbox"/> Application Data Sheet. See 37 CFR 1.76 | | |

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

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|---|------------------------|
| <input checked="" type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. | FILING FEE AMOUNT (\$) |
| <input checked="" type="checkbox"/> A check or money order is enclosed to cover the filing fees | |
| <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge underpayment or credit any overpayment to Deposit Account Number: 50-0665 | 80.00 |
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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

 No. Yes, the name of the U.S. Government agency and the Government contract number are: _____

Respectfully submitted,

SIGNATURE

Date

11/3/03

TYPED or PRINTED NAME

Chun M. Ng

REGISTRATION NO.

36,878

(if appropriate)

TELEPHONE

(206) 359-8000

Docket Number:

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DRIVER FOR LIGHT SOURCE HAVING INTEGRATED PHOTOSENSITIVE
ELEMENTS FOR DRIVER CONTROL

TECHNICAL FIELD

[0001] This invention relates to an integrated light driver having photosensitive feedback capability.

BACKGROUND

Integrated circuits (ICs) are widely used to efficiently control the power delivered to a lighting element, notably when the lighting element is used in a application where at least one of the following criteria apply:

- Limited physical space makes the usage of a set of discrete components difficult
- Battery operation requires efficient power conversion for longer unplugged autonomy
- Environmental regulations require efficient in-use power conversion, and very low stand-by power consumption
- Cost of the set of discrete components is an issue

The integrated circuits developed for the specific task of energizing a lighting element are often referred to as a “driver” of the lighting element. For example, integrated circuit drivers are commonly used to energize cold cathode fluorescent lights (CCFLs), electroluminescent (EL), and LED lighting devices, which are themselves used to provide backlight for liquid crystal displays (LCDs). These LCDs are found in many size-sensitive applications such as mobile electronics (laptop computer, pocket computer, cell phone) or flat panel monitors or TVs.

As energy-saving environmental regulations become more stringent, these IC drivers are also naturally finding their way into more mainstream applications such as general lighting. The range of applications for drivers is thus expanding, for example, to hot cathode fluorescent light (the traditional "neon lamp") or low-intensity nightlight devices.

BRIEF DESCRIPTION OF THE DRAWINGS

DETAILED DESCRIPTION

[0002] In the following description, numerous specific details are provided, such as the identification of various system components, to provide a thorough understanding of embodiments of the invention. One skilled in the art will recognize, however, that the invention can be practiced without one or more of the specific details, or with other methods, components, materials, etc. In still other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of various embodiments of the invention.

[0003] Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearance of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

The present invention combines an IC driver with photosensitive elements. The photosensitive elements are integrated onto the same package or even the same monolithic integrated circuit die as the IC driver. This provides significant cost, size, and power consumption advantages over traditional discrete component based feedback solutions.

Discrete photosensitive elements, such as photodiodes are widely used in electronic devices, to gather information on the quality and quantity of the light emitted by a given source. In some applications, this information is fed back into a separate discrete integrated circuit or other electronic device that controls the electrical power delivered to the lighting

element. This allows controlling or otherwise adjusting other components in the application, in order for instance to provide enhanced performance of said application. However, this approach is costly and bulky.

The present invention is a fully integrated solution (as opposed to using discrete elements) to energize (drive) a lighting element while providing information on local light conditions through a photosensitive element or a set thereof, so as to provide enhanced performance for a given application. The performance enhancement may be quantified by, for instance, but not limited to, one or several of the following benefits:

- i. Improved user experience, by providing “physiologically consistent” lighting of the application regardless of the level of ambient light and/or of the state of the application itself (such as being “cold” or “warm”).
- ii. Improved overall energy efficiency of the application, by continually optimizing the power delivered to the lighting element, depending on the level of ambient light and/or of the state of the application itself.
- iii. Improved lifetime of the lighting element, by reducing unnecessarily elevated power loads in a fashion described in (ii), thus reducing the overall wear of said lighting element.
- iv. Improved reliability of the overall application, by enabling the monitoring and comparing the lighting element’s performance over time vs. a known performance reference, thus allowing the trigger of an early warning when the lighting element is reaching its end-of-life.

To summarize, the present invention teaches an integrated circuit featuring:

- at least one photosensitive element

- at least one electrical power management circuit (driver) to control the intensity of an external lighting element or set thereof

In other embodiments, the photosensitive element and driver are enclosed in:

- a package that has at least one transparent section allowing light to reach the photo-sensitive element

In yet other embodiments, the apparatus of the present invention also includes:

- means to adjust the output of the driver based upon the input of photosensitive element

In yet other embodiments, the apparatus of the present invention is formed on a monolithic integrated circuit.

In yet other embodiments, the apparatus of the present invention is composed of two or more integrated circuits assembled in the same package.

In yet other embodiments, the apparatus of the present invention is used where the external lighting element is a cold cathode fluorescent light (CCFL) or a set thereof.

In yet other embodiments, the apparatus of the present invention is used where the external lighting element is a light emitting diode (LED) or a set thereof.

In yet other embodiments, the apparatus of the present invention is used where the external lighting element is an electroluminescent (EL) device or a set thereof.

In yet other embodiments, the apparatus of the present invention is used where the external lighting element is a organic LED or set thereof, included an entire display made of such.

In yet other embodiments, the apparatus of the present invention is used where the external lighting element is a halogen lamp.

In yet other embodiments, the apparatus of the present invention is used where the external lighting element is an incandescent lamp.

In yet other embodiments, the apparatus of the present invention is used where the external lighting element is a laser-based device.

In yet other embodiments, the apparatus of the present invention is used where the external lighting element is a plasma-based device.

In yet other embodiments, the apparatus of the present invention is used where light is brought from the user environment onto a photo-sensitive element.

In yet other embodiments, the apparatus of the present invention is used where the light collected on the photosensitive element is used to adjust the brightness of the light emitting device, so as to automatically provide optimum lighting conditions for the user.

In yet other embodiments, the apparatus of the present invention is used where light emitted by the controlled light emitting element is brought onto the photosensitive element.

In yet other embodiments, the apparatus of the present invention is used where the light collected on the photosensitive element is used to determine the working conditions of the lamp, such as early failure warning.

In yet other embodiments, the apparatus of the present invention is used where the light collected on the photosensitive element is used to determine both the working conditions of the lamp, such as early failure warning, and the to adjust the brightness of the

light emitting device, so as to automatically provide optimum lighting conditions for the user

In yet other embodiments, the apparatus of the present invention is used where both light from the user environment is brought onto a first photosensitive element, and light from the light emitting element is brought onto a second photosensitive element.

In yet other embodiments, the apparatus of the present invention is composed of an integrated circuit where:

- the light brought from the user environment onto a first photosensitive element is used to adjust the brightness of the light emitting device, so as to automatically provide optimum lighting conditions for the user, and
- the light brought from the light emitting element onto a second photo-sentive element is used to further adjust the brightness of the light emitting device, so as to automatically provide further optimum lighting conditions for the user.

In yet other embodiments, the apparatus of the present invention is used where the application is a portable or wearable electronic device such as, but not limited to, a laptop computer, a pocket computer, a personal digital assistant, a cell phone, a digital cameral, a global positioning system (GPS), a camcorder, a personal music player, a gaming device, or video goggles or visor.

In yet other embodiments, the apparatus of the present invention is used where the application is a generally stationary (e.g., in a home) or otherwise embedded electronic (e.g., in an automobile) device such as, but not limited to, a computer monitor, a flat panel TV, a gaming console, a general purpose lamp, a low intensity night light, an advanced remote control unit, a GPS, a dashboard or a part thereof, or a heads-up display system

Examples of the IC drivers can be found in our U.S. Patent No. 6,633,138 to Shannon et al. (driver for CCFL), our co-pending U.S. Patent Application Serial No.

10/685,132 entitled "NEGATIVE CHARGE PUMP" filed October 14, 2003 (driver for white LED), U.S. Patent Application Serial No. 10/677,612 entitled "FIXED OPERATING FREQUENCY INVERTER FOR COLD CATHODE FLUORESCENT LAMP HAVING STRIKE FREQUENCY ADJUSTED BY VOLTAGE TO CURRENT PHASE RELATIONSHIP" filed October 2, 2003 (driver for CCFL), and U.S. Patent Application Serial No. 10/626,994 entitled "VOLTAGE REGULATOR USING A TRANSIMPEDANCE BLOCK TO MEASURE OUTPUT" filed July 24, 2003 (driver for photoflash), each of which is assigned to the assignee of the present invention and herein incorporated by reference in their entirety.

The photosensitive elements described herein may be of any type normally formed onto an integrated circuit, such as photodiodes, pinned photodiodes, photogates, charge coupled devices and the like. As one example, a photodiodes can be formed simply as an n-type region formed over a p-type region. Incident light will cause charge to flow across the photodiode. This charge can then be read out as a current or voltage using known techniques. In any event, the photosensitive elements can be formed on an integrated circuit, and in accordance with one embodiment of the present invention, formed on the same integrated as the driver.

From the foregoing, it will be appreciated that specific embodiments of the invention have been described herein for purposes of illustration, but that various modifications may be made without deviating from the spirit and scope of the invention. Accordingly, the invention is not limited except as by the appended claims.

CLAIMS

I/We claim:

1. A monolithic integrated circuit formed on a single unitary die, said integrated circuit comprising:
 - (a) at least one photosensitive element formed on said single unitary die; and
 - (b) at least one electrical power management circuit to control the operation of an external lighting element.
2. The monolithic integrated circuit of Claim 1 further including a package enclosing said monolithic integrated circuit, said package having at least one transparent section allowing light to reach the photosensitive element.
3. The monolithic integrated circuit of Claim 2 further including means to adjust the output of the power management circuit based on the output of said photosensitive element.

DRIVER FOR LIGHT SOURCE HAVING INTEGRATED PHOTORESISTIVE
ELEMENTS FOR DRIVER CONTROL

ABSTRACT OF THE DISCLOSURE

Figs. 1a and 1b: Example of a **non-monolithic** integrated circuit featuring an Electrical Power Management Circuitry (b) for a lighting element, a plurality of photosensitive elements (a1) and (a2), and a partially transparent package allowing light to be incident onto the photosensitive elements

Fig. 1a: Integrated circuit (IC) shown without top encapsulation

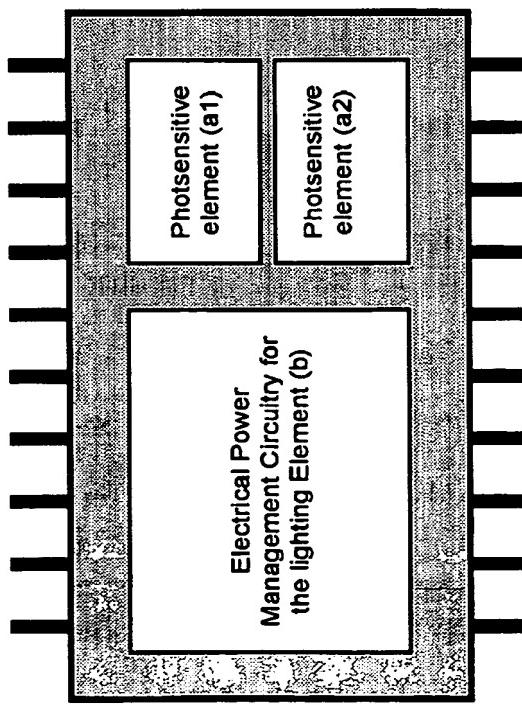
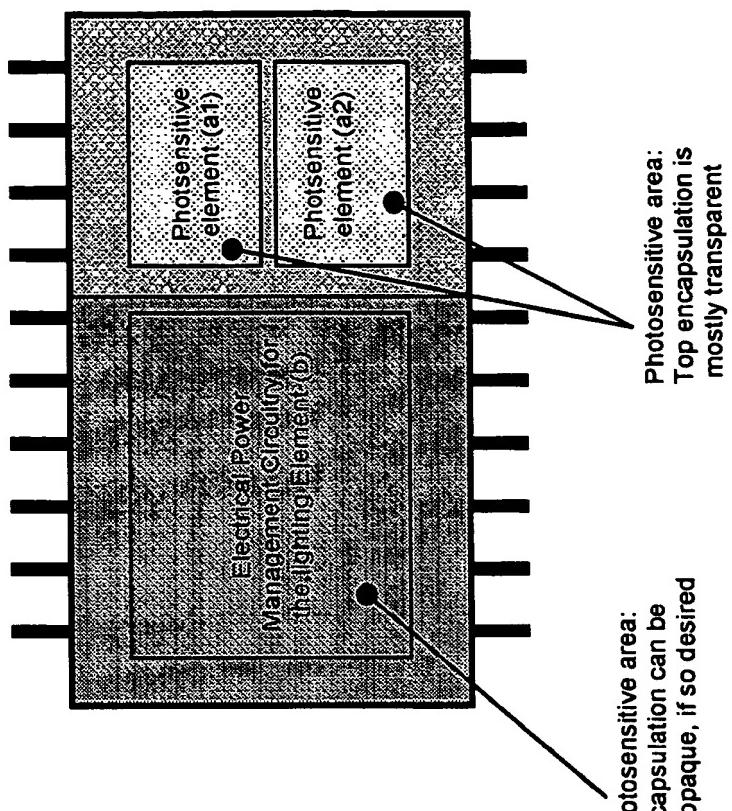


Fig. 1b: IC shown with partially transparent top encapsulation



Non-photosensitive area:
Top encapsulation can be
mostly opaque, if so desired

Photosensitive area:
Top encapsulation is
mostly transparent

Figs. 2a and 2b: Example of a monolithic integrated circuit featuring an Electrical Power Management Circuitry (b) for a lighting element, a plurality of photosensitive elements (a1) and (a2), and a partially transparent package allowing light to be brought onto the photosensitive elements

Fig. 2a: IC shown without top encapsulation

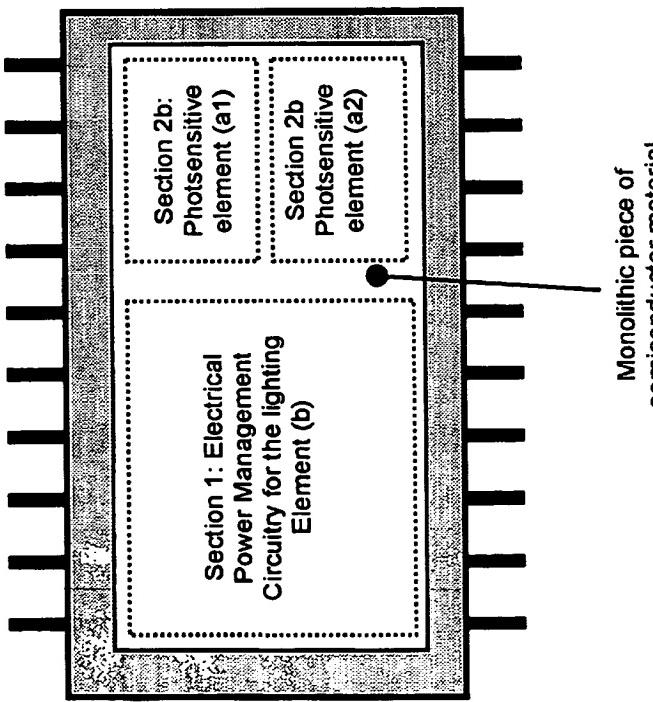


Fig. 2b: IC shown with partially transparent top encapsulation

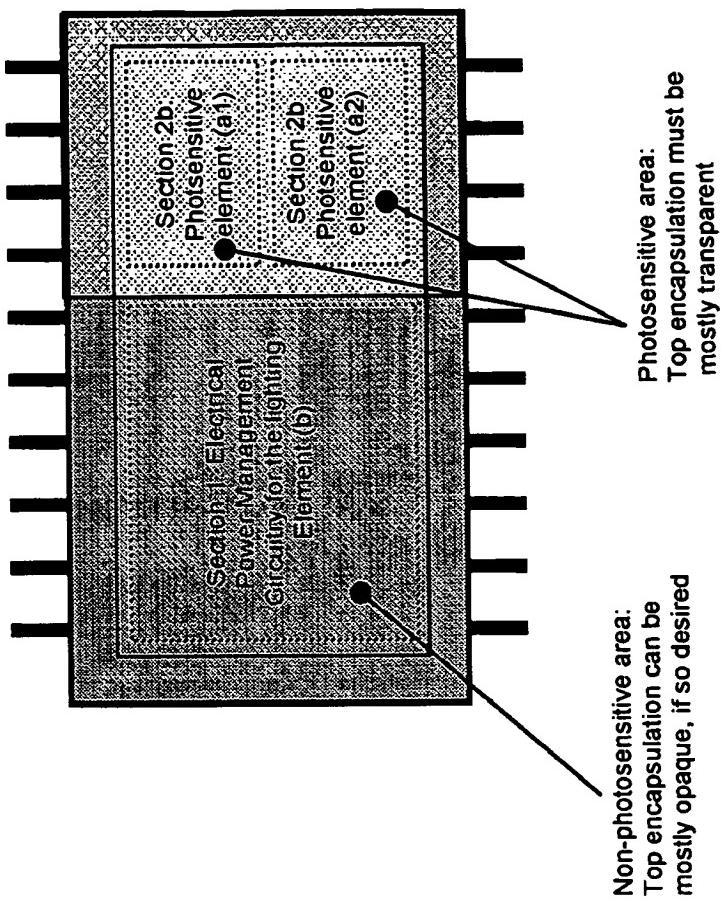


Fig. 3: Example of implementation of the invention in a display, where a small, simple window is made in the frame of the display which contains the integrated circuit. Ambient light readily reaches one of the photo-sensitive elements.

The photosensitive element provides an electrical signal proportional to the intensity of the ambient lighting conditions to the power control section. The latter then uses this information to adjust the electrical power provided to the lighting element, so as to automatically provide lighting suitable for the application.

For instance, the lighting element would be dimmed in dark indoor conditions, and brightened in sunny outdoor conditions.

Note that the window and chip orientation may alternatively face the rear of the display, so as to optimize the contrast between the display and the actual field of view of the user

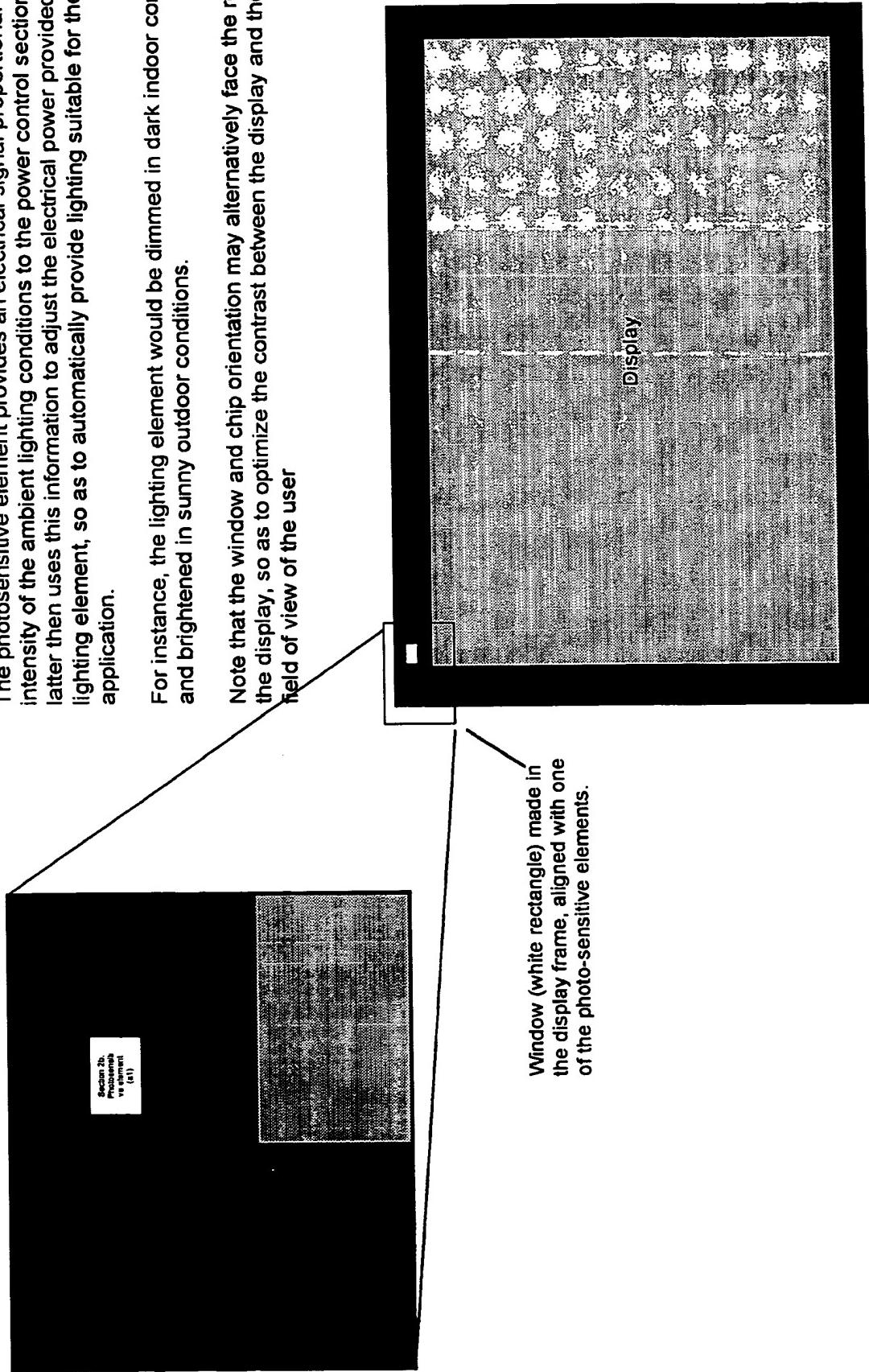
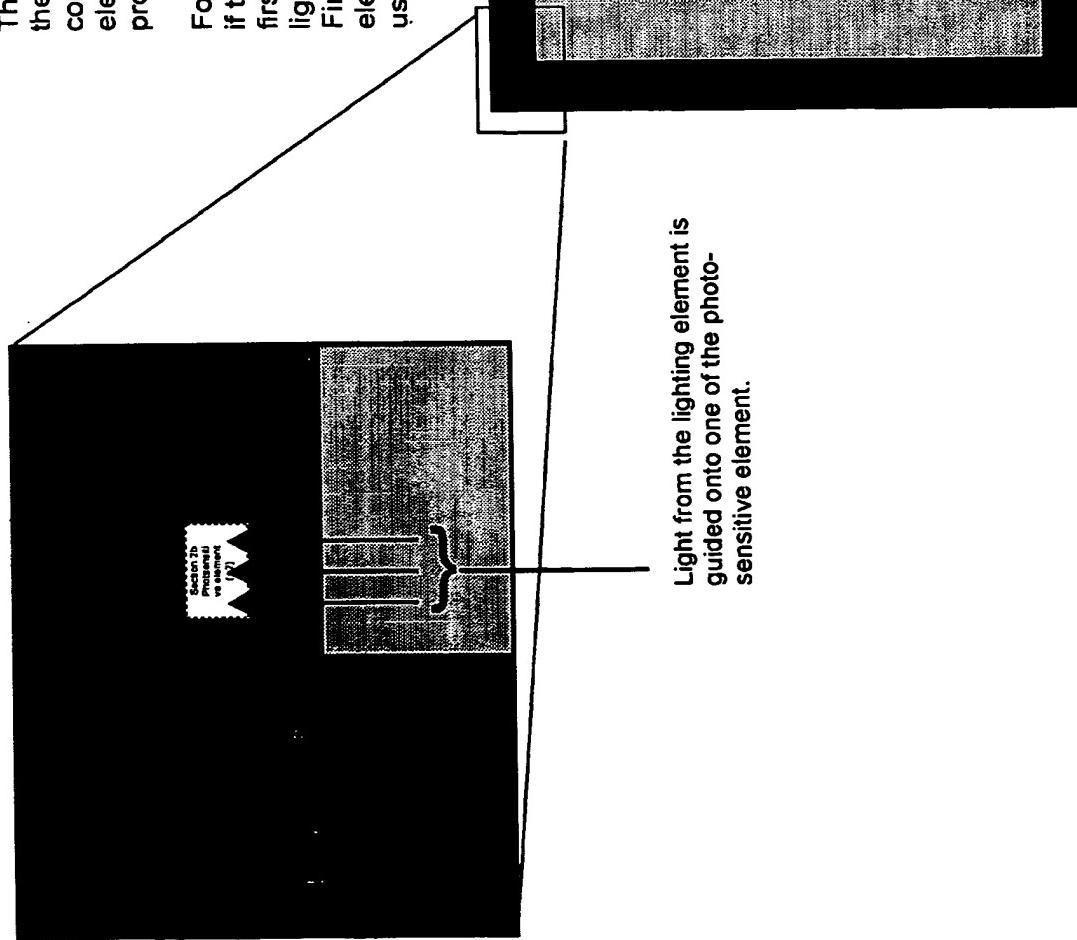


Fig. 4: Example of implementation of the invention in a display where the frame contains said integrated circuit. In this case, a fraction of the light generated by a lighting element (such as, but not limited to, a CCFL or an array of LED) is brought onto one of the photo-sensitive elements, either directly or through a simple light-guiding structure.

The photo-sensitive element provides an electrical signal proportional to the intensity of the light emitted by the light emitting element, to the power control section. The latter then uses this information to adjust the electrical power provided to the lighting element, so as to automatically provide lighting suitable for the application.

For instance, the power section could provide higher power upon startup if the lighting element is a CCFL, which is traditionally dimmer during the first few minutes of operations. Likewise, more power could be fed to the lighting element as it ages and tends to loose its light-emitting efficiency. Finally, comparing the actual steady-state brightness of the lighting element with a set reference would provide an early failure warning to the user.



Light from the lighting element is guided onto one of the photo-sensitive element.

Fig. 5: Example of implementation of the invention in a display, where both features described in Fig. 3 and Fig. 4 are implemented.

The photo-sensitive elements need to be photoisolated from each-other, so as to avoid interference between the two light feedback paths, i.e., the one from the environment, and the one from the lighting element itself. This can be achieved by simple mechanical means that will not be described in this application for the sake of simplicity and readability

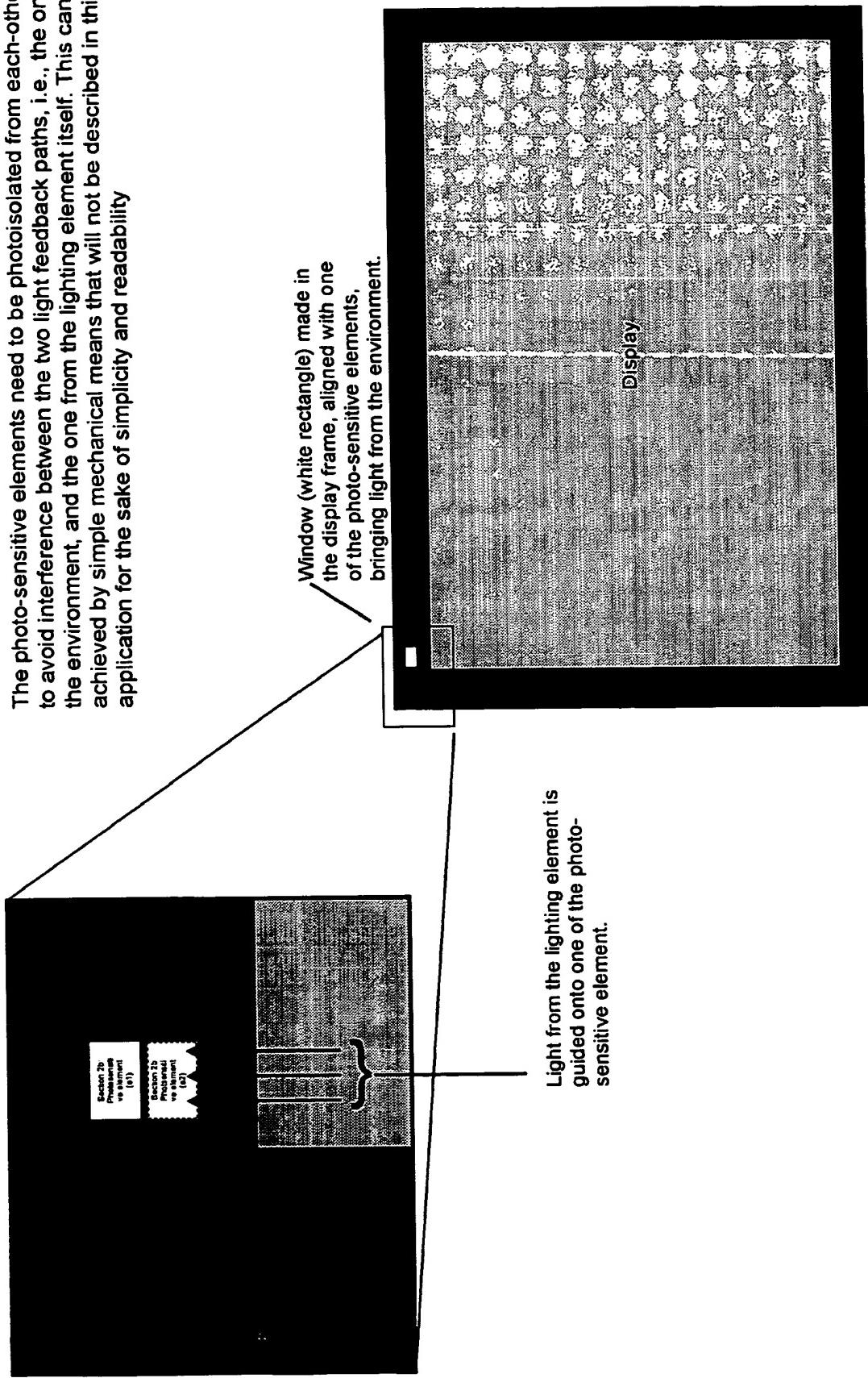
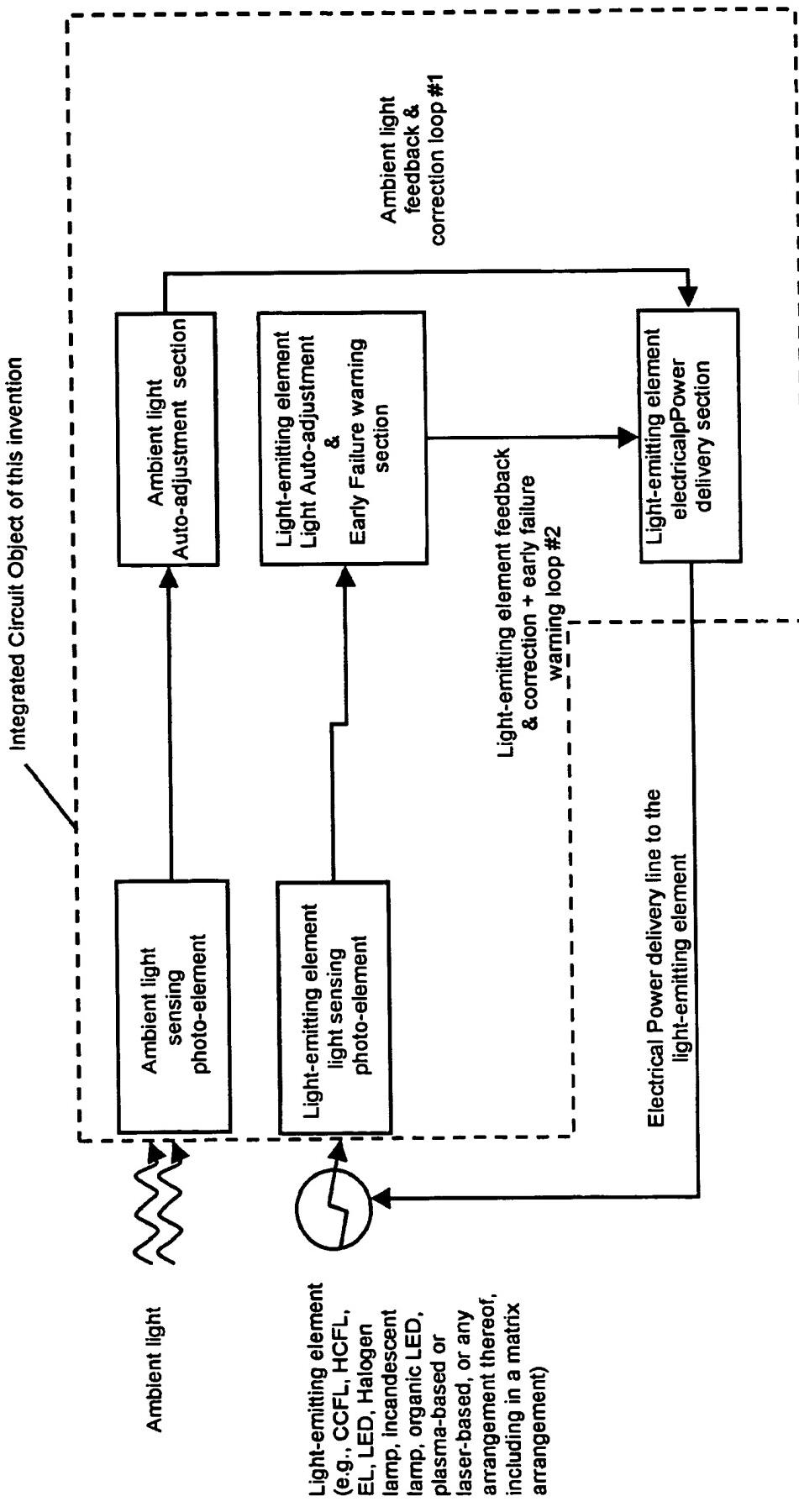
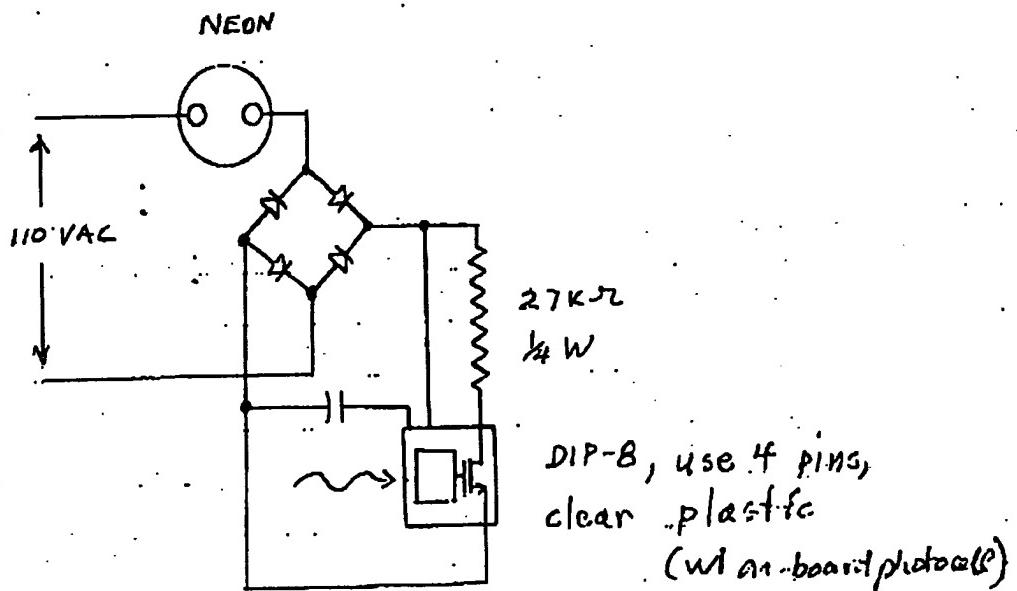
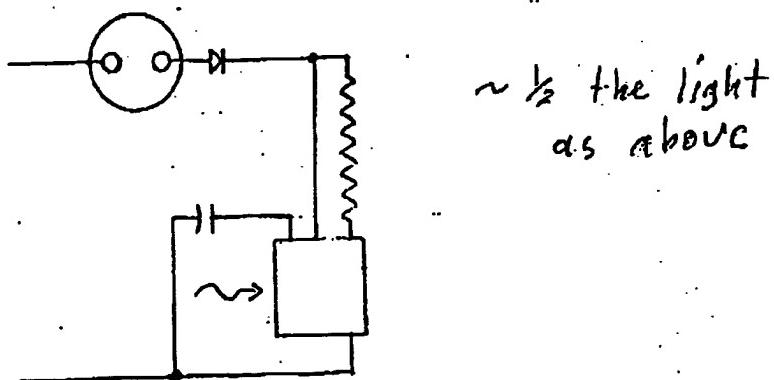


Fig. 6: Schematic of the basic operating principle of the invention. The invention may be implemented with both light-emitting element brightness adjustment loops #1 and #2, or just one. The integrated circuit may be monolithic, i.e., made out on the base of a single, solid piece of semiconductor material, or may combine several distinct monolithic sections set in a same package.





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